

Effect of Stimulus Modality on the Performance on Working Memory Tasks in Children

Nisha Melempatt Lohithakshan¹, Nuggehally Puttaveeraiah Nataraja²

¹Ph.D. Research Fellow, ²Director & Professor,
J.S.S. Institute of Speech and Hearing, J.S.S. Research Foundation, Mysuru, Karnataka, India

Corresponding Author: Nisha Melempatt Lohithakshan

ABSTRACT

Working memory is a system for temporarily storing and managing the information required to carry out complex cognitive tasks such as comprehension, reasoning, and learning. The processing of the visual and auditory stimuli is different at the input stage, but the downstream effect of these differences in cognitive processing is unclear. The present study has compared the performance of the participants on the working memory tasks when the stimulus was presented through auditory and visual modality. The study included 60 typically developing children, in the age range of 9-10 years, with Malayalam as their mother tongue and medium of instruction at the school. The results have revealed that the performance on the working memory tasks was better when the stimuli were presented through the visual modality than the auditory modality.

Key Words: Memory, Working Memory, Visual modality, Auditory modality, Auditory word retrieval, Word span.

INTRODUCTION

Memory, one of the important cognitive processes, plays a vital role in language comprehension and expression. Memory has been defined as stored representation and the process of encoding, consolidation, and retrieval through which knowledge is acquired and manipulated. [1] Baddeley and Hitch [2] have classified memory as long-term memory, short term memory, and working memory. Baddeley [3] has defined working memory as the temporary storage of information necessary to perform tasks such as comprehension, learning, and reasoning. Working memory capacity has been related to several cognitive tasks such as language processing, math skills, learning abilities, and verbal reasoning skills. [4] More specifically, working memory has been considered as critical for learning, reasoning, reading comprehension, following a conversation, and problem-solving skills necessary to

meet the challenges of post-secondary education. [5-6] Working memory has been found to play an important role in language development and academic success in children. [7]

Modality of presentation of stimulus may influence the performance on working memory tasks. The review of the literature has demonstrated that the underlying cognitive processes involved in auditory and visual tasks are often different. And it has also been reported that the visual presentation of the stimuli would result in improved learning and recall performance than the auditory presentation of the stimuli. Constantinidou and Evripidou [8] concluded from their study on 10-12 year old Greek children that the performance was better when the stimuli were presented through visual modality than through auditory modality. [9] Studies by Constantinidou and Neils [10] and Constantinidou, Neils, Bouman, Lee, and Shuren [11] had shown

that young normal subjects and young subjects with moderate brain injury had performed significantly better during the visual presentation of information. Specifically, the recall and recognition performance had improved during the visual-only and auditory plus visual presentations compared to the auditory presentation alone. Furthermore, the visual presentation was the most resistant to the effects of interference. [12] Amon and Bertenthal [13] reported that the responses to visual stimuli were faster but less accurate than the responses to auditory stimuli.

The review of the literature has also revealed that though working memory has drawn the attention of researchers, the influence of stimulus modality on performance on working memory tasks has been less explored. Considering the importance of working memory in language development and academic skills, the present study has attempted to explore the effect of stimulus modality on performance on working memory tasks.

Aim of the study

The present study aimed at assessing the performance on working memory tasks, in 9-10 year-old typically developing Malayalam speaking children, by presenting the stimuli through auditory and visual modalities. The objectives of the study were to (1) assess the working memory through auditory modality and visual modality using auditory word retrieval and word span respectively among typically developing Malayalam speaking children and (2) Compare the performance on auditory working memory and visual working memory tasks in these children.

METHOD

The present study was designed to evaluate the effect of stimulus modality on the performance on working memory tasks in typically developing Malayalam speaking children in the age range of 9-10 years.

Participants

The current study included 60 typically developing children in the age range of 9-10 years, selected randomly from Malayalam medium schools at Shoranur, a semi-urban area in Palakkad district, Kerala, India. All the children had Malayalam as their mother tongue and medium of communication/instructions at home and school. All the participants had normal hearing sensitivity and normal visual acuity with a normal motor, speech-language, cognitive skills, and average/good academic performance as reported by the teachers and parents. Further, it was confirmed by the examinations by a qualified speech language pathologist and audiologist.

PROCEDURE

The working memory was assessed by presenting the stimulus through auditory modality as well as visual modality. The purpose and method of the study were explained to the parents of the children included in the study and written informed consents were obtained from each parent. The study also had approval from the Ethics Committee of the Institute for Communicative and Cognitive NeuroSciences (ICCONS), Shoranur, Kerala. The testing was carried out in a quiet room in the school. The working memory through auditory modality was assessed using auditory word retrieval and the same through visual modality was assessed using word span.

The auditory word retrieval task included 20 words that were selected from the Malayalam textbook of fourth grade. The stimuli selected were concrete words with 2-4 syllables in each word. The task was arranged as a series of words in five levels and the complexity of the task was increased at each level with two words in level I and six words in level V. The second, third, and fourth levels had three, four, and five words respectively as stimuli. For assessing auditory word retrieval, the participants were instructed, in Malayalam, to remember and repeat the words in the

same order presented by the investigator orally. The instructions were repeated with the trial stimulus whenever it was felt that the participants had not understood the instructions. The participants who could not follow the instructions even after repetition were dropped out of the study. The participants repeated the series of words delivered orally by the investigator at each level. The responses were recorded using Sony digital voice recorder ICD-UX560F for offline analysis and the researcher also noted down the correct responses. Each correct response was given a score of 1 and the maximum score for the task was 20.

Similarly, the word span task included 20 Malayalam words selected from the Malayalam textbook of fourth grade. The stimuli selected were concrete words with 2-4 syllables in each word. The stimuli were arranged as a series of words in five levels with two words in level I and six words in level V. The second, third, and fourth levels had three, four, and five words respectively as stimuli. For assessing the word span, the participants were instructed, in Malayalam, to read and remember the words presented by the investigator and then repeat the words read. The typed stimuli were presented using a laptop monitor. The instructions were repeated with the trial stimulus whenever it was felt that the participants had not understood the instructions. The participants who could not follow the instructions even after repetition were dropped out of the study. The responses were recorded using Sony digital voice recorder ICD-UX560F for offline analysis and the researcher also noted down the correct responses. The maximum score for the task was 20 and each correct response produced by the participant was given a score of 1.

Thus, using these procedures, working memory through auditory modality and visual modality were assessed in each of the participants i.e., all the 60 participants performed the tasks, and scores of each participant in terms of auditory word retrieval and word span were analyzed.

Statistical Analysis

The data obtained were subjected to descriptive statistical analysis to obtain the mean scores and standard deviation and an Independent t-test were carried out to find out the effect of stimulus modality on working memory performance.

RESULT

The performance of auditory word retrieval and word span were investigated as the total number of correct responses. The mean and standard deviation are presented in Table I.

Table 1: The mean and standard deviation (SD) values for Auditory Word Retrieval and Word Span

	Mean	Standard Deviation
Auditory Word Retrieval	14.97	2.19
Word Span	16.95	2.39

As given in table 1, a higher mean value of 16.953 (SD=2.39) was observed for word span and the mean value for auditory word retrieval was 14.97(SD= 2.19). The minimum score obtained for auditory word retrieval was 11 and the maximum score obtained was 19 with a median value of 15. The lowest score for word span was 12 and the highest score obtained was 20 with a median value of 17. The results revealed that the working memory performance was better when the stimulus was presented through visual modality (Word Span task) than auditory modality (Auditory word retrieval task).

An Independent t-test was carried out to understand the significance of variation across auditory modality and visual modality. The t-test revealed that there was a significant effect of stimulus presentation modality on working memory performance, $t(59) = -4.74382$, $p < .00001$; $d = 0.86$. The result was statistically significant at $p < .05$. The effect size for this analysis ($d = 0.86$) was found to exceed Cohen's [14] convention for a large effect ($d = .80$).

DISCUSSION

The results of the study revealed that there was an advantage for visual modality

on working memory performance. These results were found to be similar to the reports of earlier studies. [8-11] Constantinidou, Neils, Bouman, Lee, and Shuren [11] reported that the maximum amount of information was learned through visual modality (Stimulus in the form of pictures), with or without the auditory presentation of information, as compared to the auditory modality alone. The visual presentation (with or without the simultaneous auditory presentation of words) resulted in superior free-recall and recognition performance as compared to the auditory presentation alone in adults. [9] Younger and older school-aged children in the age range of 7-13 years learned better during the visual presentation modality. The auditory-plus-visual presentation modality yielded similar results as the visual presentation alone. [15] Klingner, Tversky, and Hanrahan [16] reported better performance on visual tasks than auditory tasks with both digit span and mental arithmetic. However, the result of the current study was not in consonance with Liebel and Nelson. [17] They reported that there was no significant difference between auditory working memory and visual working memory functioning among adults with an average age of 23.48 years (SD=7.58). The difference in results may be attributed to the variations in the age groups involved in the studies.

The advantage of stimulus presentation through visual modality may be attributed to the considerable reliance on verbal rehearsal as well as the generation of the images from long term memory. [18] It was also to be noted that visual stimuli were spontaneously named such that both visual and auditory representations of the stimuli were retained. [19-20]

CONCLUSION

The outcome of the study indicated that to maximize the working memory performance, the stimulus may be presented through visual modality and this information may be used while planning

therapeutic intervention in disordered population. It may also be noted that the working memory varied across age and hence future research on a larger age group has been recommended. Future research on the clinical population has also been warranted.

Author Note

The authors declare that there is no conflict of interest regarding the publication of this manuscript and the research work has obtained ethical approval from the Institution Ethics Committee (IEC).

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